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Structural Building Element

DESCRIPTION

The invention relates to structural building elements formed from cold-rolled lightweight sheet steel. Such building elements, made to a constant profile, are known lightweight alternatives to hot-rolled steel girders and may be built up into structures with a high strength-to-weight ratio.

Lightweight sheet steel can be cold-rolled into a variety of different useful profiles. C-shaped profiles are very useful, as they can be joined together in a variety of ways to make up structures that have a good resistance to bending and excellent strength-to-weight ratios. A typical C-section profile would comprise two front wall portions extending outwardly from a central slot opening; a pair of lateral sides; and a rear portion joining together the lateral sides. If desired, a swage may be provided in the rear portion and optionally in the lateral sides, which increases the strength appreciably without increasing the weight. If desired, the front wall portions may be inturned along the line of the central slot opening, which further increases the strength and rigidity of the profile. Such profiles are made by cold-rolling, which creates a radiussed fold or bend between the generally flat front walls and the flat lateral sides and between the lateral sides and the flat rear portion, but as a generality the practice has been to keep the radii of those bends as small as possible, to create building elements that are generally rectangular in overall section.

It is an object of the invention to increase further the strength of such structural building elements, without adding to the overall weight.

The invention

The invention provides a structural building element as defined in claim 1 herein. The building element of the invention uses curves wherever possible in place of the flat faces of known C-shaped profile building elements. The overall profile of the

building elements according to the invention is preferably a continuous arcuate curve, without any creases or sharp bends, from the inner edge of one of the front wall portions, out in an arcuate path embracing the whole of the associated lateral side and joining the concave arcuate or substantially arcuate rear central wall portion, before continuing symmetrically around to the inner edge of the other wall portion on the opposite side of the central slot opening. In such a building element the depth of the element from front to back is equal to the diameter of the arc shared between the front wall portions, the lateral sides and the mutually outer extremities of the rear portion. As an alternative, however, each of the lateral sides may have a flat portion centrally thereon, the front portions joining the flat portions tangentially. That gives the building element a greater depth than the diameter of the arcs of the opposite sides. If desired, the concave arcuate or substantially arcuate rear central wall section may be formed with a central flat portion, merging tangentially with arcuate concave portions on either side of that flat portion. That gives the building element a potentially greater width than one with a totally arcuate formation throughout.

The building elements according to the invention may be made from sheet steel of thickness 2 mm or less down even to .05 mm. Preferably they are made from sheet steel of thickness about 0.8 mm.

It will be appreciated that because the structural building elements of the invention have not flat faces, or alternatively if their only flat faces are the flat portions centrally on the lateral or back sides, then conventional joining techniques for securing together such building elements to a grid-like framework become very difficult. The invention therefore further provides a range of connectors for connecting together the structural building elements according to the invention. Two such building elements can be connected together in a T- or L-configuration using a connector as specified in claim 6 herein. Alternatively three such elements can be connected together in a cross or a K-configuration, using a connector as specified in claim 8 herein. Any of the connectors can be made from lightweight sheet steel, preferably by press-forming. Preferably the leg portions join the jaw elements along an arcuate edge of the material from which the connector is made. That is to say, if the connector is first stamped out

from sheet steel as a flat blank, that blank will be generally T-shaped or L-shaped, X-shaped or K-shaped but whatever the shape the internal angles would be cut not as abrupt angular changes in direction of the edge of the material from which the connector is made, but would be rounded to create a smooth transition in the line of the edges of the portion of the blank to be pressed into the jaw elements, and the portions to be pressed into the leg portions. During pressing, this arcuate gusset of sheet metal is cold-stretched to form the junction between two curved sections extending in mutually perpendicular directions (namely the jaw element and the associated leg portion) each of which has been press-shaped to its own profile. In some cases this cold-stretching may be sufficient to bring the material of the two side portions into contact with one another, in which case they may be spot-welded at their zone of contact. This adds very considerably to the overall strength and rigidity of the joint formed by a connector according to the invention between two or more structural building elements according to the invention.

The structural building elements of the invention can be used, together with the connectors of the invention which join them together, in the construction of modular buildings, mobile homes, commercial racking, building joists, lattice beams, partition walls, floors, ceilings, roofs, mezzanine floors, staircases, steel framed furniture, workbenches, masts, pylons, gantries, stage lighting frameworks and scaffolding. Many other uses will become apparent from the true potential is explored of the ability to join together linear struts at angles other than 90°.

Drawings

Figure 1 is a perspective view of a structural building element according to the invention;

Figure 2 is a cross section through the structural building element of Figure 1;

Figure 3 is a cross section through a slightly altered profile of a structural building element according to the invention;

Figure 4 is a cross section through another slightly altered profile of a structural building element according to the invention;

Figure 5 is a cross section through yet another slightly altered profile of a structural building element according to the invention;

Figure 6 is a perspective view of an upright structural building element according to the invention with a pair of profiled spurs formed from structural building elements according to the invention connected to the structural upright at a high level and in the main plane of the structural upright and with a similar profiled spur connected to the structural upright at a low level and perpendicular to the main plane of the structural upright;

Figures 7a, 7b and 7c are respectively a plan view from above, a front elevation and an end elevation of one half of the connector used to join the pair of profiled spurs of Figure 6 in the main plane of the structural upright; and

Figures 8a, 8b and 8c are respectively a plan view from above, a front elevation and an end elevation of a strengthening strap shown in Figure 6;

Figures 9a, 9b and 9c are respectively a plan view from above, a front elevation and an end elevation of the connector used to join the profiled spur of Figure 6 perpendicular to the main plane of the structural upright;

Figure 10 is a perspective view of a structural upright formed from a structural building element as shown in Figure 5 with profiled spurs extending perpendicularly therefrom at high and low levels;

Figure 11 is a plan view from above of a structural building element of Figure 1 with a spur extending therefrom at an angle of 45° to the main plane of the structural building element;

Figure 12 is a perspective view of one side portion of the asymmetric connector shown in Figure 11;

Figure 13 is a side elevation of a lattice beam made from structural building elements according to the invention;

Figure 14 is a perspective view of one connector used to make the lattice beam of Figure 13;

Figure 15 is a plan view from above of two structural building elements according to Figure 5 made up into a rectangular section column; and

Figure 16 is a horizontal section through a triangular pylon structure that may be made from three upright structural elements according to Figure 1.

Referring first to Figure 1, a structural building element 1 is shown which has been formed from cold-rolled lightweight sheet steel and has a generally C-shaped profile. The profile is constant along the length of the building element 1 which may be made much longer than that shown in Figure 1. The building element has, generally speaking, a pair of front wall portions 2a and 2b; a pair of lateral sides 3a and 3b; and a rear portion 4. The front wall portions 2a and 2b extend laterally outwardly from a central slot opening 5, and each follows the arc of a circle from its inturned inner edge 6a or 6b, around onto and over the lateral side 3a or 3b to the rear portion 4. The rear portion 4 is a sinusoidal wall in which the convex arcs just described merge with a concave arcuate central rear wall portion 7.

The same section is shown in greater detail in Figure 2 which illustrates how the circles (shown in broken line) which the arcuate front and side walls follow touch but do not overlap. One possible variation of the shape is shown in Figure 3, where it can be seen that the lateral sides 3a and 3b include flat sections, with the front portions joining the flat sections tangentially and the convex elements of the sinusoidal rear portion also joining the flat sections tangentially. Two other possible variations of the sectional shape are shown in Figures 4 and 5, where it can be seen that the rear wall portion 7 includes a flat section, with the concave portions one on each side of the central flat section joining the flat section tangentially. The flat section of the rear wall portion can be of variable width, as illustrated in Figures 4 and 5. Alternatively the flat sections of Figures 3 to 5 may be formed not completely flat but as continuous curves of larger radius than the circles shown in Figure 2 in broken line.

The curves of the structural building elements according to the invention provide a very much stronger and more versatile building element than the conventional flat-faced C-section profiles. The building elements may be used as structural uprights or as joists or beams, and their advantages are numerous. They may be joined together in lattice frameworks using pressed steel connectors according to the invention, with a far greater potential strength and a vastly greater flexibility of design than conventional C-section cold rolled lightweight steel structural building elements

which have a generally rectangular box-like section with a central slot opening along one side.

To create T- or L- or X- or K-connections between structural building elements according to the invention, individual connectors are provided. Figure 6 shows one X-configuration junction and one L-configuration junction. The X-configuration junction, at the upper half of Figure 6, shows how two structural building elements 1a and 1b according to Figure 1 are connected to extend laterally one from each side of a third structural building element 1c according to Figure 1 positioned as a structural upright. The elements 1a and 1b are in the main plane of the element 1c, aligned with a plane passing centrally through both of the side walls 3a and 3b of Figure 1. The L-configuration junction, at the lower half of Figure 6, shows how a fourth structural building element 1d is connected to extend perpendicularly from the main plane of the element 1c.

Figures 7a to 7c illustrate the shape of the connector used to create the X-configuration junction of Figure 6. The connector is made in two identical halves 10, only one of which is shown in Figures 7a to 7c. It is formed from cold pressed steel, which may be the same gauge steel as that of the elements 1a to 1c or of a heavier gauge metal. Each half 10 of the connector may be spot-, plug- or seam-welded to the structural upright 1c in a jig, for example, and then the side elements 1a and 1b simply inserted between the pairs of spurs which extend laterally from the upright 1c, and welded into place.

Figures 9a to 9c similarly illustrate the shape of the connector used to create the L-configuration junction of Figure 6. The connector is made in two identical halves 11, only one of which is shown in Figures 9a to 9c. It is formed from cold pressed steel, like that of Figures 7a to 7c, but is preferably welded to the side element 1d in a jig before the assembly of the element 1d and the connector halves 11 is offered up to the structural upright 1c and welded to that upright. The opposite sides of the connector formed by the two halves 11 lap around the side walls of the structural upright 1c by preferably more than 180°, so that the union can be self-supporting prior to welding.

Figure 6 also shows a strap 12 which can be welded across the front of the structural building element according to the invention. The shape of the strap 12 is illustrated in Figures 8a to 8c. The provision of a number of such straps along the length of the structural building elements according to the invention greatly increases the strength. In particular, one such strap immediately above and one immediately below a junction such as that shown in the lower half of Figure 6 greatly enhances the strength of the junction, as the two halves 11 of the connector are effectively held together by the strap 12.

Figure 10 illustrates other variants of the connectors 11 and straps 12 that are possible. The connector 11a at a high level of Figure 10 has jaws which pass around the curved front and inside arc of one arcuate portion of a structural upright building element 1 and around the curved arcuate outer wall of the same arcuate portion, as opposed to straddling opposite outer side walls as in Figure 6. The connector 11b at a low level of Figure 10 has jaws which straddle opposite outer side walls as in Figure 6, but the laterally extending spurs which support the horizontally extending structural element 1 by contacting the outer side walls of that horizontal element 1 as opposed to the front and rear faces as in Figure 6.

Figure 10 also shows how an extended strap 12a can straddle two parallel structural building elements 1; how a strap 12b can be formed with a central stamped-out inturned flange 25 which is spot-welded to a flat rear mid-portion of a structural building element 1 shaped as shown in Figure 4 or Figure 5; and how a strap 12c can be formed with a deep-drawn dimpled portion 26 which is deep enough to contact an inside of the rear wall 7 of a structural building element 1 according to Figure 2 (not shown) or a similar dimpled portion 26 of another strap 12 (not shown). Where the dimpled portion 26 contacts the rear wall 7 or another dimpled portion 26 the contacting zones are spot-welded together for greater rigidity.

Figure 10 also shows how a strengthening member 30 can be inserted longitudinally down the centre of any arcuate curved wall of any structural building element 1

according to the invention. The strengthening member 30 can be a rod or tube, to enhance both tensile strength and compression resistance in the axial direction, or it may be a wire or cable under tension to enhance tensile strength alone. If the structural building elements of the invention are made to create a building module to be built up into a framework for example as disclosed in W068004 then such a strengthening member 30 can be inserted in selected structural uprights of the building module, and preferably is provided with a screw-threaded protruding portion 31 as shown in Figure 10, so that each strengthening member can be screw-connected to that immediately above. Thus vertical reinforcement can be provided, extending the whole height of the building and effectively locking successive storeys together. Similar bracing or reinforcement can be provided in the horizontal plane, by passing strengthening members 30 through the arcuate curved walls of horizontally disposed elements 1.

Figures 6 and 10 show how the connection between the structural upright 1c and the side members can be in the main plane of the structural upright or perpendicular to that main plane. However the system of the invention is sufficiently flexible that all other angles may be accommodated. Figure 11 shows a junction in which a side element 1e extends from a structural building element 1c of the invention at an angle of 45° to the main plane X-X of the element 1c. The joint is created using a connector made in two portions, 13a and 13b. The two portions are not symmetrical, as each comprises a jaw portion 14 partially to surround the outside side wall of the structural element 1c, and a spur portion 15 to encase a front or rear side of the side element 1e. The arcuate extents of the jaw portions 15 are different as between the portions 13a and 13b. Figure 12 illustrates the shape of one of the two portions. Both portions of the connector can be simply pressed from sheet steel, and preferably a location hole 16 is punched into each of the connector portions 13a and 13b during pressing, or during stamping out of the blank for pressing, with another such hole accurately positioned in the structural upright element 1c so that assembly of the junction at the accurate angle is simply assured by aligning the holes, inserting a rivet into the aligned holes to obtain a temporary securing of the two connector halves 13a and 13b to the upright element 1c, and then welding the connector firmly into position before

sleeving the cross-element 1e between the spur portions 15 and welding that in place. Alternatively the connector portions 13a and 13b can be welded to the side element 1e in a jig before being presented up to the upright element 1c, when optionally holes such as the hole 16 can be used to provide a temporary fixing by rivet before welding up the junction.

The structural building elements according to the invention can be made up into lattice beams such as that shown in Figure 13 using K-configuration connectors which create a junction of less than 90° between the axis of the main structural building element and the axis of each of two side elements. One such connector is illustrated in Figure 14. It is made in two halves 17a and 17b, each pressed from lightweight sheet steel. The halves 17a and 17b when placed together define three tubular cavities, 18, 19 and 20. The cavity 18 is a continuous tubular cavity extending from one end to the other of the connector, and in use surrounds one arcuate side of a structural building element 1 as shown in Figure 5 for example. The structural element 1 of Figure 14 is shown as passing only half way through the connector but that is for illustrative purposes only. In practice the connector would be positioned mid-way along the length of an element 1. The cavities 19 and 20 are blind cavities each inclined at 45° to the axis of the cavity 18 and of the element 1. The cavities 19 and 20 receive respective arcuate sides of two further structural building elements 1 (not shown) of identical size and shape to the element 1 shown in Figure 15. If desired for additional strength another such connector can be used to connect together the other arcuate sides of the three structural building elements 1, to build up the lattice beam of Figure 13. Advantageously the sheet steel of the connector halves is deep-drawn to an extent such that the mating halves contact each other, as shown at 21, and the two halves are spot-welded together in those zones of contact for increased strength.

Figure 15 shows how two straps 12 similar to those of Figures 6 and 8a to 8c but with a longer length can be used to join together two structural building elements 1 into a rectangular configuration. This creates a strong pillar for a building, and its strength

may be reinforced if necessary against compressive loads by forming the structure around a pre-cast and optionally reinforced concrete core 22.

Figure 16 shows a triangular pylon structure that may be made from three upright structural building elements 1 according to Figure 1, connected together by cross-braces 1 which are also of the same cross-sectional form as the uprights and. which are connected to the uprights by connectors as shown in Figures 9a to 9c or as shown in Figure 14. If desired, braces 12 (shown in chain-dotted line) can be added to the outside for added strength. The upright elements 1 may be truly vertical and mutually parallel, or may be mutually inclined to one another to create an upwardly tapering pylon. Figure 16 illustrates the flexibility of the structural building elements of the invention when used in association with the connectors as illustrated. The angles between the connectors and the main plane of the structural elements can be varied at will, and the angles between the axes of the connected structural elements can be varied by varying the angle shown in Figure 14 as 45°. This gives the designer the flexibility of a free choice of angle in all three axes when constructing each joint in a lattice system.